

# ***TOPIC B – PART 6***

## ***HORMONES***

IB Chemistry  
Topic B – Biochem



# B6 Hormones - 3 hours

- B.6.1 Outline the production and function of hormones in the body. (2)
- B.6.2 Compare the structures of cholesterol and the sex hormones. (3)
- B.6.3 Describe the mode of action of oral contraceptives. (2)
- B.6.4 Outline the use and abuse of steroids. (2)

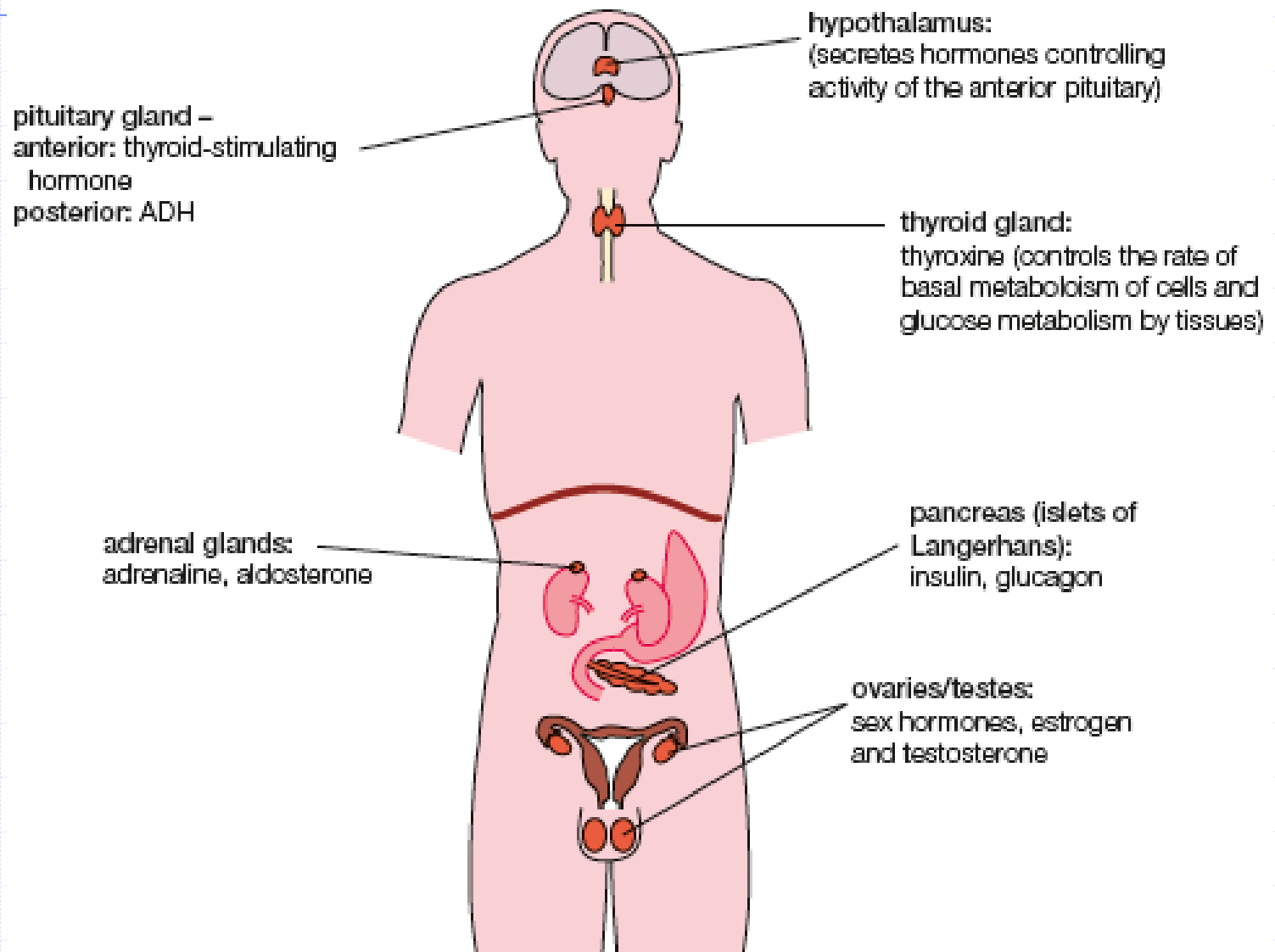


# B6.1 – Hormone Production/Function

- *B.6.1 **Outline** the production and function of hormones in the body. (2)*
- **Hormones** are chemical messengers
- Hormones are produced and secreted from the cells of ductless or **endocrine gland**
- Transported in the blood stream but only target and act on specific organs
- In very small amounts in blood but control many body functions and activities
- Specifically cause changes in metabolism of the target organs



# B6.1 – The Endocrine System



# B6.1 – Endocrine Functions

Hormone	Secreting organ/tissue/cells	Function or activity
ADH	Posterior pituitary	Promotes water reabsorption by kidneys and controls blood osmolarity
Aldosterone	Cortex of the adrenal gland	Regulates salt excretion by kidney; controls blood pressure
Estrogen	Ovaries	Development of the female secondary sexual characteristics and control of the menstrual cycle
Progesterone	Corpus luteum of the ovary	Regulates activity in female reproductive organs during menstrual cycle and pregnancy
Testosterone	Testes	Sperm production
Insulin	Pancreas (Islets of Langerhans)	Stimulates glucose uptake and usage
Epinephrine (adrenaline)	Medulla of the adrenal gland	Controls response to stress, increases heart rate
Thyroxine	Thyroid gland	Stimulates metabolism in many tissues

**Table 22.7** Selected human hormones



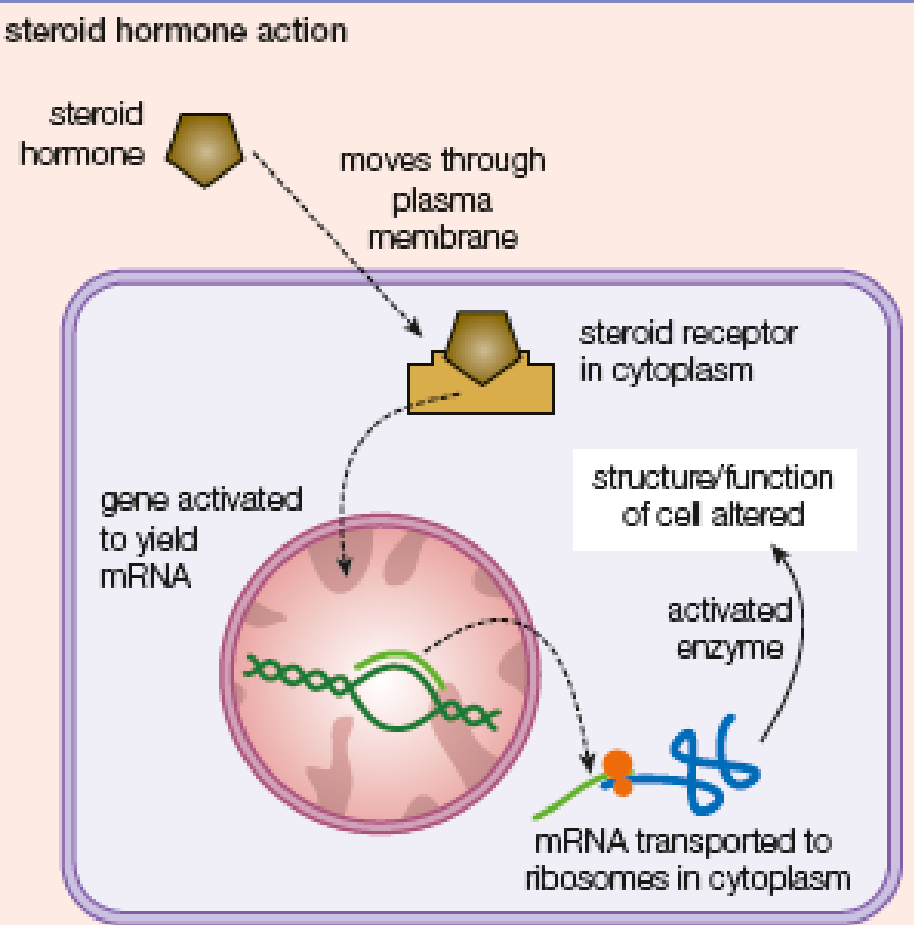
# B6.Ex – Hormone Mechanisms

- Chemical analysis of hormones shows they fall into two groups:
  - Steroids (ex. sex hormones)
    - ◆ Move across the membrane (as they are non-polar) to activate specific genes, causing protein synthesis
  - Peptides (small proteins like insulin and ADH)
    - ◆ Bind to the protein membrane receptors, activating existing proteins in the cytoplasm



# B6.Ex – Hormone Mechanisms

## Steroid Hormone Action



## Amine/peptide Hormone Action

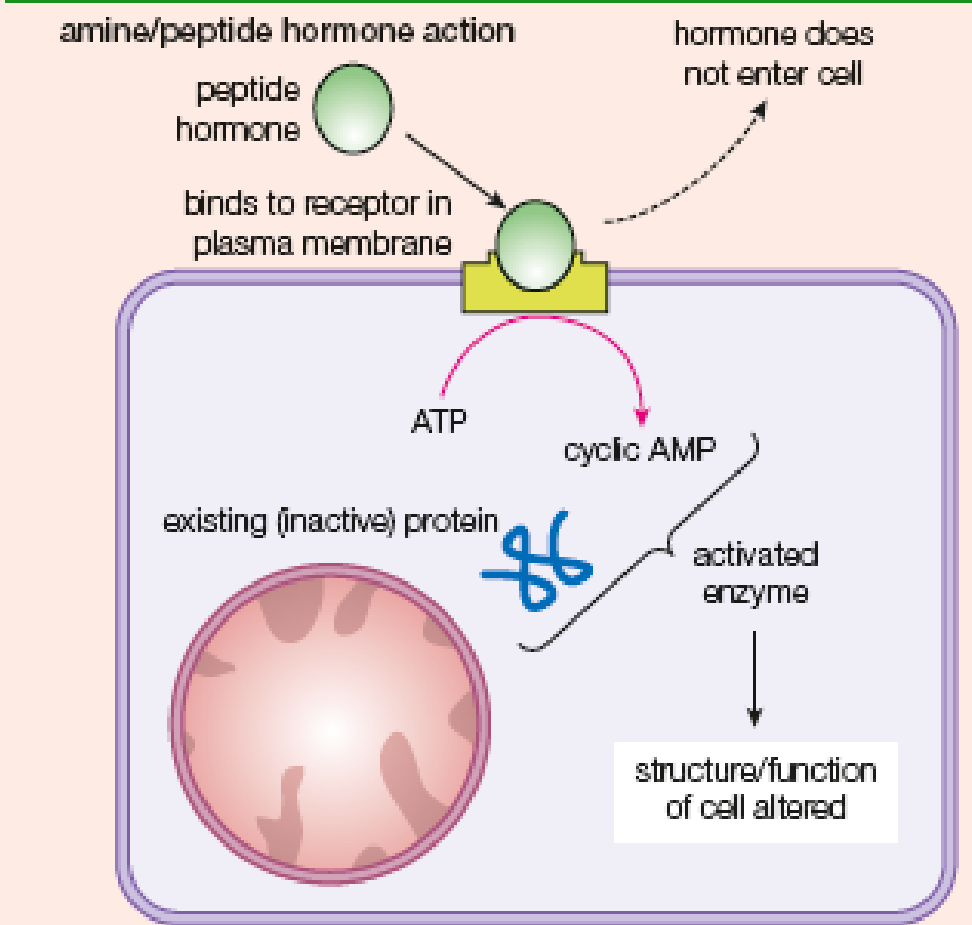


Figure 22.70 The action of steroid and peptide-based hormones

# B6.2 – Structures of Cholesterol/Sex Hormones

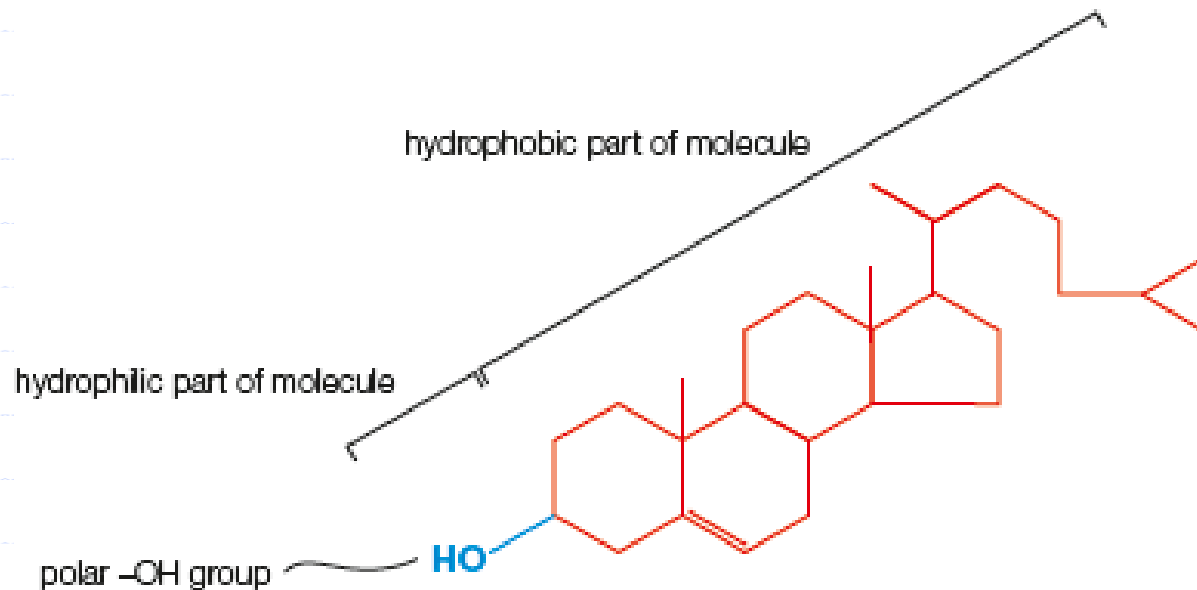
- *B.6.2 Compare the structures of cholesterol and the sex hormones. (3)*
- **Sterols** are structural **lipids** present in the membranes of animal and plant cells
  - **Four** fused rings
    - ◆ **3** x cyclohex(ane)
    - ◆ **1** x cyclopent(ane)
- **Cholesterol** is the major sterol in animal tissue





# B6.2 – Cholesterol Structure

- Remember, as we have already seen, that steroids (although they don't look like lipids) are in the same category
- Due to its insolubility, cholesterol is transported through the blood in the form of lipoproteins



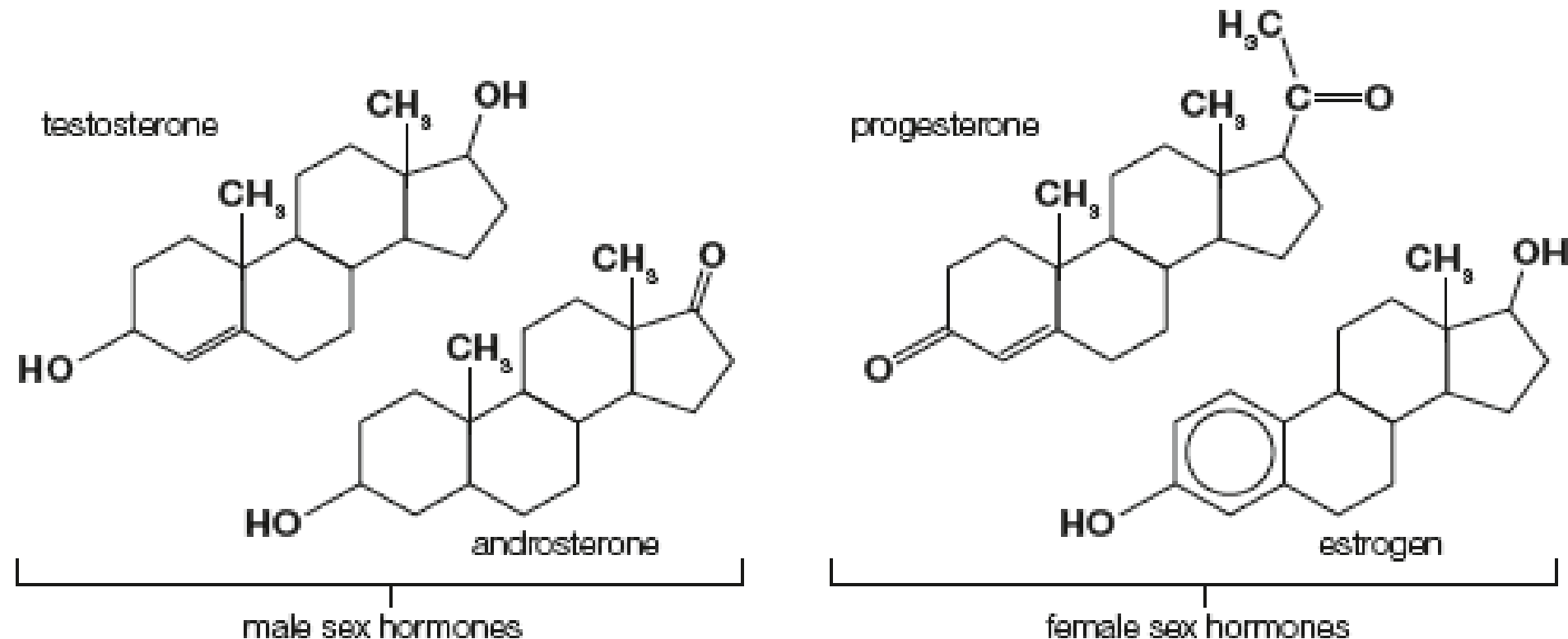
# B6.2 – Cholesterol vs Sex Hormones

- Cholesterol
  - In cells and tissues, synthesized as required
  - In mammals, obtained through a diet of meat and lipids. Also synthesized in the liver
- Sex Hormones
  - **Male Sex Hormones, testosterone and androsterone**
    - ◆ Produced in the testes and derived from cholesterol
  - **Female Sex Hormones, progesterone and estrogen**
    - ◆ Derived from cholesterol as well



## B6.2 – Sex Hormone Structure

- Each of the sex hormones has a similar structure to that of Cholesterol with differing functional groups and alkene features

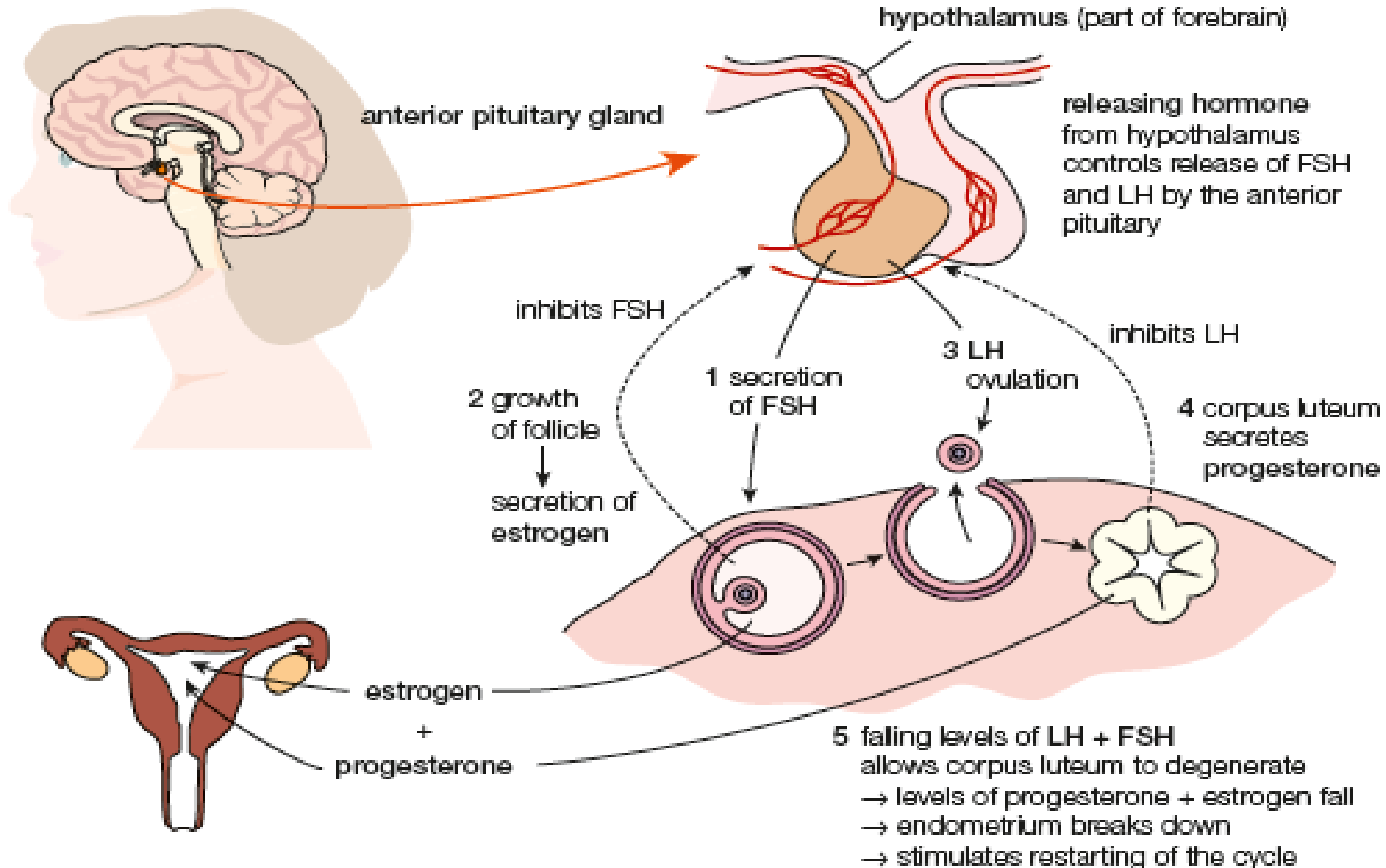


## B6.3 – Oral Contraceptives

- *B.6.3 Describe the mode of action of oral contraceptives. (2)*
- At the start of the menstrual cycle the **pituitary gland** in the brain releases **follicle stimulating hormones** (FSH)
  - **FSH** is secreted into the **blood stream** and enters the **ovaries** where it causes a fluid-filled sac known as a **follicle** to produce an **ovum** (egg).
  - The developing follicle releases **estrogen**, to prepare the release of the ovum (egg) and thickening of the **uterine lining** (endometrium).



# B6.3 – Contraceptive Action



## B6.3 – The Cycle Continues (2)

- After about two weeks, FHS production stops (via negative feedback mechanism) and **luteinizing hormone** (LH) is produced.
- **LH** is then transported via the blood stream to the **ovaries** where it stimulates **ovulation** from the follicle
- The remains of the follicle are transported to a body called the **corpus luteum** (a temporary endocrine gland that secretes **progesterone**)



## B6.3 – The Cycle Continues (3)

- **Progesterone** causes the ovum (egg) to travel to the uterus and the uterine wall to continue building.
- If the ovum is **not fertilized**, the corpus luteum breaks down, the ovum degenerates and menstruation begins
  - **Menstruation** washes away the ovum and the uterine lining
- If the ovum **is fertilized** it embeds itself in the **uterine wall** and overall hormone levels rise dramatically



## B6.3 – Oral Contraceptives

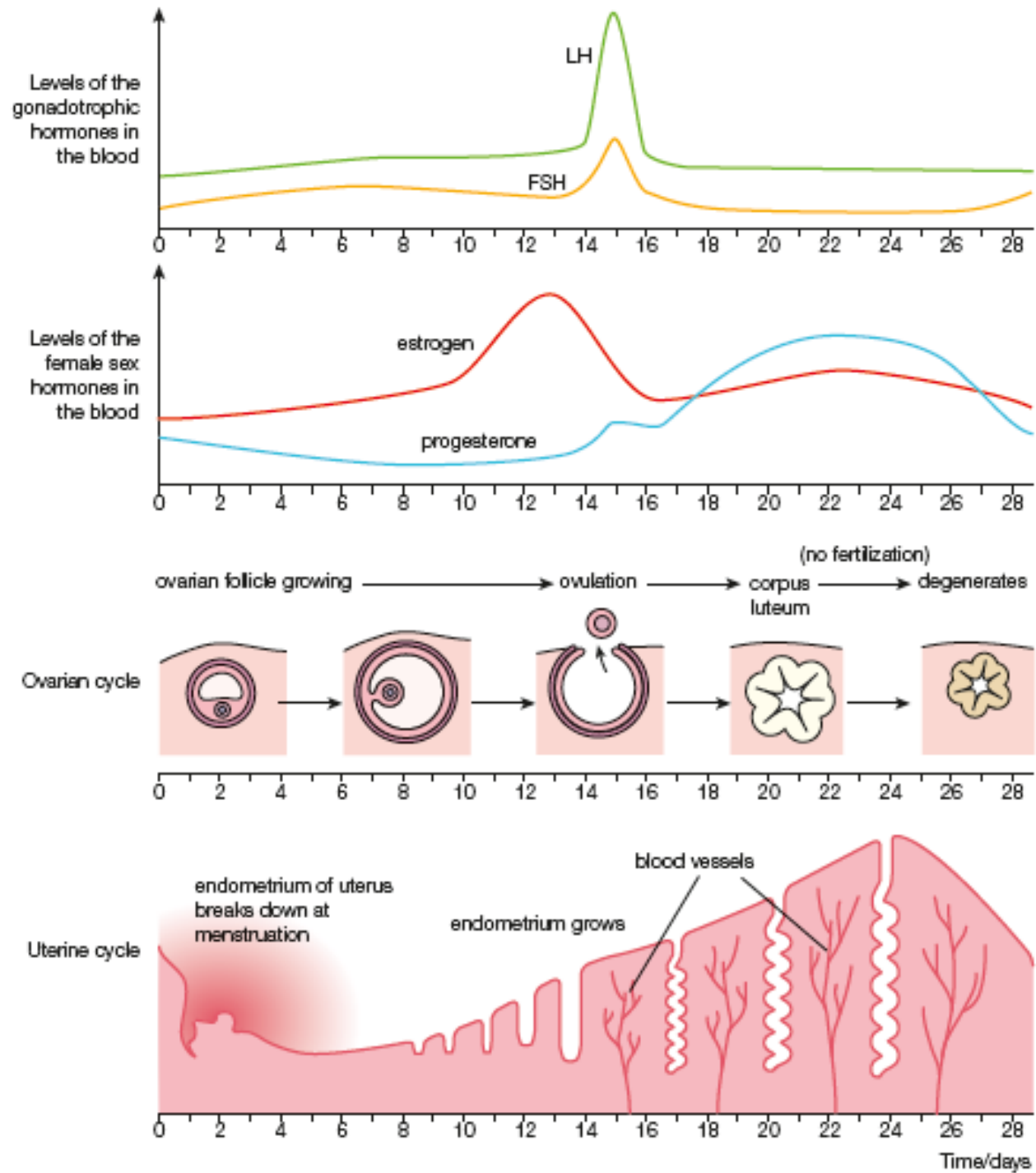
- The use of some oral contraceptives **inhibits the production** of **FSH** (follicle stimulating hormones) and **LH** (lutenizing hormones). Each of these causes the release of the ovum (egg)
- Another option (and the original method) is to supplement **progesterone** which tricks the body into thinking it's already pregnant and therefore not releasing a new ovum (egg) that month
- Both options regulate the menstrual cycle by introducing heavy amounts of hormones to the body. This must be maintained or the body may compensate for 'delayed ovulation'





# B6.3 – Hormone Levels

- This figure demonstrates the changing levels of hormones in the body throughout the monthly menstruation cycle



## B6.4 – Steroid use, good and bad

- *B.6.4 **Outline** the use and abuse of steroids. (2)*
- In the 1920's it had been established that the testes produced a hormone which was responsible for the male characteristics.
- It was called **testosterone** and studies began. First complete synthesis was achieved in 1935
- Testosterone is responsible for:
  - sexual development in males
  - stimulating growth and protein synthesis in muscles
  - production of red blood cells by the bone marrow



## B6.4 – Silly Nazis!!



- Reports of Nazi soldiers that were fed synthesized hormones have been published all over, true or not, it's funny
- Supposedly, Nazi soldiers were fed synthetic testosterone in hopes to create strong troops for the "master race"
- Unfortunately for the Nazis (and fortunate for us) testosterone is a steroid-based hormone and hence poorly soluble in water, so supplemented it was flushed out of the system and had little effect on the soldiers

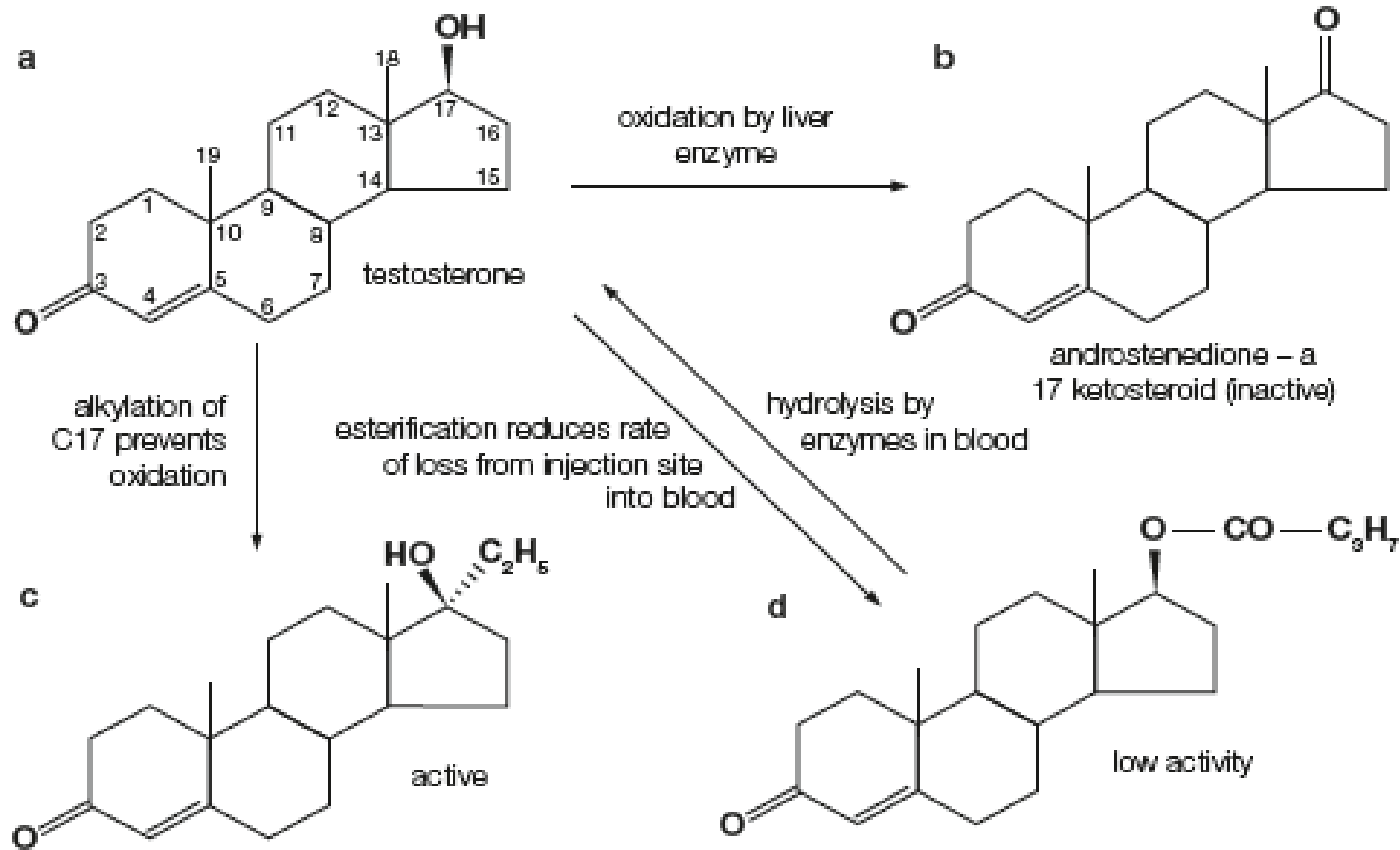


## B6.4 - Testosterone

- Testosterone is naturally broken down in the body to an **inactive** compound called '**17-ketosteroids**' which differs from testosterone by having a **ketone** at position 17 instead of a **primary alcohol**
- Researchers found that by substituting the hydrogen atom on carbon 17 with an **alkyl group** (ethyl or propyl), the testosterone derivative could last much longer in the body with the same biological effects.



# B6.4 – Testosterone Derivatives



# B6.4 – Other Testosterone Derivatives

- More complex ester derivatives of testosterone have also been synthesized by introducing various chemical groups at positions 1, 2, 9, 11.
- These are known as **anabolic steroids**
  - Resistant to breakdown by enzymes that destroy (metabolize) testosterone
  - Shape is different so they don't bind to the active site of the enzymes (proteins) that catalyze testosterone oxidation



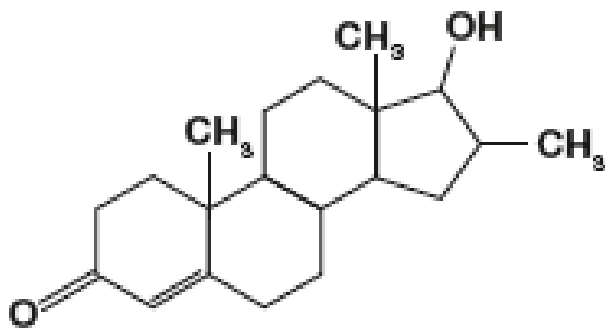
## B6.4 – Anabolic Steroids

- Anabolic Steroids
  - Increase muscle bulk and stimulate competitiveness
  - Maintained well when drugs are taken in training and stopped before competition
  - Detected in urine through GC-MS
  - If used in women, they develop muscle features, deep voice, body hair, rough skin, stop period
  - Men develop acne, premature baldness, prone to heart attacks
  - Banned in the 1976 Olympic Games

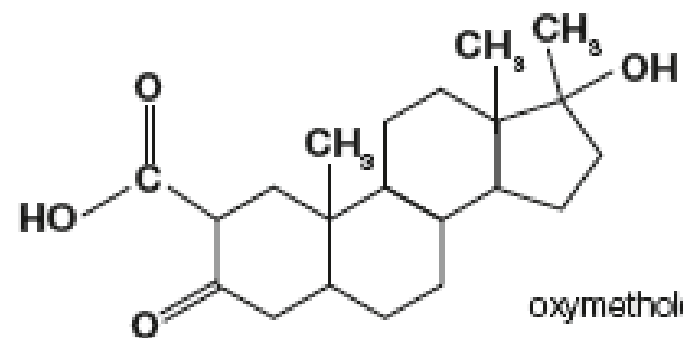


# B6.4 – Therapeutic use of Steroids

- Therapeutic use of anabolic steroids:
  - Bone marrow stimulation (lukemia, kidney failure)
  - Stimulation of growth (for growth failures)
  - Stimulation of appetite and increase in muscle mass, for patients with chronic wasting conditions such as AIDS
  - Hormone replacement therapy, for treating men with low levels of testosterone



methyltestosterone



oxymetholone